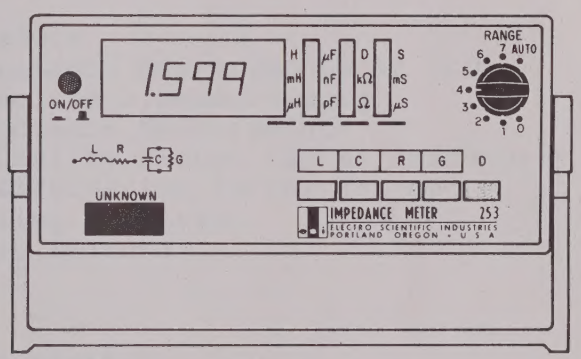
Instruction Manual

AUGUST 1978
Replaces March 1978

MODEL 253

Autoranging Digital Impedance Meter



Part Number 43761

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13900 N.W. Science Park Drive • Portland • Oregon 97229 • U.S.A.
Telephone: (503) 641-4141 • Telex: 36-0273

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WARNING

DANGEROUS VOLTAGE POTENTIALS EXIST INSIDE THIS INSTRUMENT. MAINTENANCE INSTRUCTIONS WITHIN THIS MANUAL ARE FOR USE BY QUALIFIED SERVICE PERSONNEL ONLY. TO AVOID ELECTRICAL SHOCK, DO NOT ATTEMPT ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATION INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

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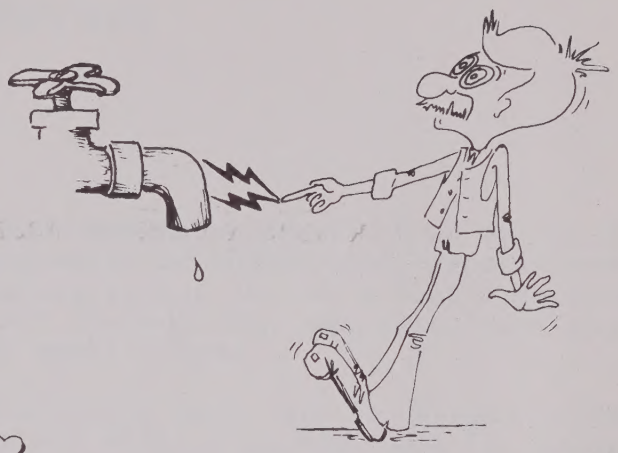
PROTECT AGAINST ELECTROSTATIC DISCHARGE

In this instrument there are MOS and FET semiconductors, which can be damaged by electrostatic discharge during handling. The following precautionary procedures are recommended to minimize this possibility.



DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES

HANDLE STATIC SENSITIVE DEVICES ONLY AT A GROUNDED, STATIC-FREE WORK STATION

HANDLE DEVICES BY THE BODY. DO NOT TOUCH THE DEVICE LEADS.

BE SURE YOUR SOLDERING IRON TIP IS GROUNDED AND DO NOT USE SOLDER-SUCKERS THAT ARE NOT ANTI—STATIC PROTECTED

AVOID HANDLING WHENEVER POSSIBLE

USE ANTI-STATIC PACKAGING FOR HANDLING AND TRANSPORT

KEEP PARTS IN MANUFACTURER'S PROTECTED CONTAINERS

DO NOT SLIDE STATIC SENSITIVE DEVICES OVER ANY SURFACE AND AVOID PLASTIC, VINYL AND STYROFOAM IN WORK AREAS

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SECTION 1
DESCRIPTION

1.1 INTRODUCTION

The ESI Model 253 Autoranging Digital Impedance Meter is an automatic instrument which permits rapid measurement of inductance, capacitance, resistance, conductance and dissipation factor (D) at a test frequency of 1kHz. Measurement accuracy and versatility satisfies the most demanding engineering or scientific applications.

This instrument has both an autoranging mode and a manual range selection mode. The autoranging feature eliminates the need for manual range selecting, thus saving time and avoiding operator errors. It is designed to measure an unknown and select the lowest corresponding range automatically, thereby providing the highest resolution display. When a series of measurements are to be made within a particular range, time can be saved by turning the range switch to the corresponding fixed range position. Front panel LED lamps indicate the unit of measurement being displayed by the 3-1/2 digit LED readout.

Operation is simple, permitting use by non-technical personnel. The user merely pushes the button for the desired function and connects the unknown. KELVIN KLIPS® test leads are included, thus ensuring true four-terminal connections.

Excellent reliability of Model 253 is assured through use of solid state devices and etched circuit board construction. Its small size is welcomed for use on benchtops where work space may be at a premium. The carrying handle tilts the unit to a convenient viewing angle. Rear panel brackets provide line cord storage and enables it to be operated in a vertical position.

1.2 SPECIFICATIONS

		Ranges							
		0	1	2	3	4	5	6	7
Full Scale Values	L_s	200 µH	2 mH	20 mH	200 mH	2 H	20 H	200 H	200 H
	C_p	200 pF	2 nF	20 nF	200 nF	2 µF	20 µF	200 µF	2000 µF
	R_s	2 Ω	20 Ω	200 Ω	2000 Ω	20 kΩ	200 kΩ	2000 kΩ	2000 kΩ
	G_p	2 µS	20 µS	200 µS	2000 µS	20 mS	200 mS	2000 mS	20 S
	D	1.999							
Accuracy (15°C to 35°C)	L_s	±[0.25% + (1 + 0.002R_s*) digits] **	±[0.25% + (1 + 0.001 R_s*)digits]					±[0.25% + (1 + 0.002R_s*) digits]	±[0.25% + (1 + 0.002R_s*) digits]
	C_p	±[0.25% + (1 + 0.002G_p*) digits] **	±[0.25% + (1 + 0.001G_p*)digits]					±[0.25% + (1 + 0.002G_p*) digits]	±[0.5% + (1 + 0.004G_p*) digits]
	R_s	±[0.25% + (1 + 0.002L_s*) digits]	±[0.25% + (1 + 0.001L_s*)digits]					±[0.25% + (1 + 0.002L_s*) digits]	±[0.25% + (1 + 0.002L_s*) digits]
	G_p	±[0.25% + (1 + 0.002C_p*) digits]	±[0.25% + (1 + 0.001C_p*)digits]					±[0.25% + (1 + 0.002C_p*) digits]	±[0.5% + (1 + 0.004C_p*) digits]
	D	±(1% + 0.002) for L or C ≥ 200 counts ±(2% + 0.010) for L or C 50 to 199 counts							±(2% + 0.010)
Test Signal	Voltage C_p, G_p	1.0 VRMS		0.1 VRMS					0.01 VRMS
	Current L_s, R_s	100 mA	10 mA	1 mA	100 µA	10 µA		1 µA	

*Digit count, same range.
**After correction for test lead zero reading.
0°C to 15°C and 35°C to 50°C: add 0.1(rated accuracy)/°C.

Table 1-1. Model 253 Specifications

Test Frequency: 1kHz ±1%.

Unknown Excitation: The 1kHz voltage (Vx) and current (Ix) levels listed in Table 1-1 are held constant by an internal amplitude control circuit.

Measurement Rate: Four per second; one second is required for first reading after connecting unknown to terminals.

Measurement Display: 3-1/2 digit LED with decimal point. Blanked for overload conditions.

Unit Display: Unit of measurement being displayed by the LED readout is indicated by front panel LED lamps.

External Bias: Rear panel terminals are provided for connection of zero to 50VDC external supply.

Static Charge Protection: Diode and resistor discharge network.

Connection to Unknown: Four-terminal, shielded, connections are provided by the supplied KELVIN KLIPS® Cable Assembly (ESI Part Number 43072).

Outputs: Analog signals of 1V per 1,000 counts, 1kΩ source resistance is available at rear panel. L, C, R or G, with simultaneous output of D for L or C.

Power Consumption: 4 watts typical.

Power Requirements: 100 to 125VAC or 200 to 250VAC, 50/60Hz.

Fuse: 1/16A, 250VAC, Type MDL Slo-Blo.

Size:
Height (with feet)	-	100mm (4 inches).
Width	-	260mm (10 inches).
Depth (overall)	-	370mm (14.6 inches).

Weight: 3.2kg (7 lb).

Suggested Accessories: Model 1412B Universal Limits Comparator.
Sorting Fixture (Model 2001) + Cable Assembly (ESI Part Number 43586).
Front Panel Dust Cover (ESI Part Number 43374).

SECTION 2

OPERATION

2.1 CONTROLS AND CONNECTORS

2.1.1 Front Panel

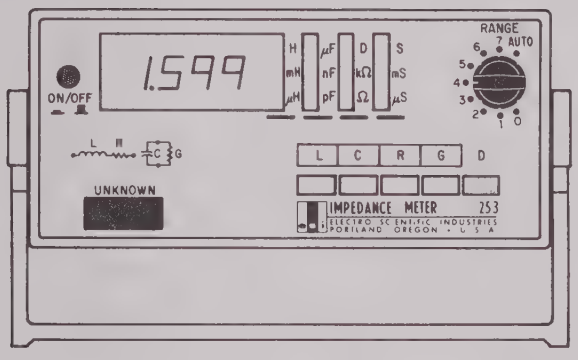


Figure 2-1. Model 253 Front Panel

ON/OFF power switch is a push-on, push-release button.

L, R, C, and G function pushbuttons select the type of meter circuit that will measure series inductance and resistance or parallel capacitance and conductance. The push-to-read D button displays dissipation factor of capacitor or inductor when C or L function is selected.

RANGE switch selects the decimal multiplier and units of measurement for the meter circuit being used. For maximum accuracy, use the range that gives the highest digital count, unless the unknown is voltage or current sensitive (see Table 1-1). The unit of measurement being displayed by the LED readout is indicated by front panel LED lamps.

The AUTO position on the RANGE switch puts the instrument in the autoranging mode. This feature enables measurement of an unknown and automatically selects the lowest corresponding range, thereby providing the highest resolution display.

The UNKNOWN terminals are designed to be used with the KELVIN KLIPS® test leads provided with Model 253. KELVIN KLIPS are color coded, one red and one black, for polarity indication when using the bias feature. Red is positive, black negative. KELVIN KLIPS provide simple, true four-terminal connection to the unknown.

2.1.2 Rear Panel

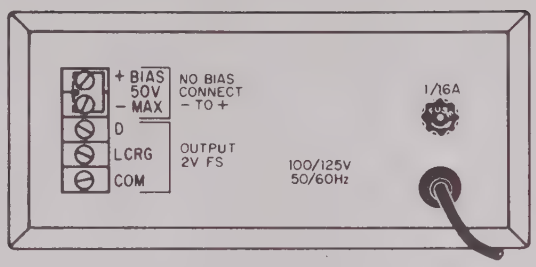


Figure 2-2. Model 253 Rear Panel

The BIAS terminals on the rear panel allow application of a zero-to-50VDC bias to the capacitor being measured. The bias voltage should be applied in the polarity indicated. The negative terminal is internally tied to case ground. The bias feature is used to measure diode capacitance, or some types of tantalum or electrolytic capacitors.

A link connects + and - terminals together when bias feature is not used. See Section 2.2.8 for bias supply requirements.

OUTPUT terminals provide two analog signals proportional to function selected (L, C, R or G) and D (for L, C only). Scale factor is 1V per 1000 counts, 1kΩ source resistance, with an accuracy of ±(0.25% of reading + 1mV). The signals can be used with an external DVM to increase full scale reading or resolution capability. They can also be used with a chart recorder to evaluate unknowns with changing impedances, or with limits comparators (ESI Model 1412B) for HI, LO, GO and HI D sorting.

2.2 OPERATING PROCEDURE

2.2.1 Preliminary

To turn the unit on, plug in the power cord and press the ON/OFF button. This will cause the front-panel readout to light. For quick connection of the unknown to the meter, plug the KELVIN KLIPS® Four-Terminal Cable Assembly into the front-panel. The connector cover is spring-locking and should be squeezed together before inserting or removing.

To tilt the handle, pull outward on its pivots and turn the handle to the desired angle. Release the pivots, and they will snap into a locked position.

2.2.2 General Procedure

Press the appropriate function button and connect the KELVIN KLIPS® to the unknown. For maximum accuracy, select the range that gives the largest on-scale reading. * When the RANGE switch is in the AUTO position, the instrument automatically selects the lowest corresponding range to give the highest resolution display. The measurement is displayed after one second or less, and repetitive measurements are made at the rate of four per second. The range LED lamps indicate the readout units (e.g. µH, mH, or H). If the value of the unknown exceeds the range selected, the display will remain blanked.

If a negative sign appears on the display when measuring an unknown, possible causes are:

- "C" button has been pushed when measuring an inductor.
- "L" button has been pushed when measuring a capacitor.
- The unknown is more capacitive (or inductive) than suspected. For example, an inductor that resonates below 1kHz will measure as a capacitor.
- A diode requires bias voltage (a negative reading may appear if bias voltage is not applied).

To measure the dissipation factor of a capacitor or inductor, push the D button while the C or L function is selected. (The display will blank if D is pushed while the unit is in R or G mode and the unknown is resistive.)

2.2.3 Notes on Resistance Measurements at 1kHz

When using the resistance function, maximum measurement capability is up to 1999kΩ. For measurements from 1999kΩ to 1000MΩ, use the G (conductance) function where G=1/R or R=1/G. Accuracy of measurement is determined by ±(0.25% + 1 digit) where 1 digit will be ±100% at 1000MΩ, ±10% at 100MΩ, and ±1% at 10MΩ.

High-value, bobbin-type, wire-wound resistors have shunt capacitance which may affect measurements by appearing as "$-L_S$". This causes some difference between ac and dc resistance measurement values.

---

*Auto is used only for the major function of the unknown, i.e. C for capacitors, L for inductors, R for resistors. If measuring minor function of the unknown, e.g. R of inductors, G of capacitor, use manual ranging.

2.2.4 Notes on Capacitance Measurements

For shielded devices, the shield should be connected to the rear panel -Bias terminal to provide proper guarding.

Most two- and four-terminal cables or sorting fixtures are not guarded immediately adjacent to where the unknown capacitor is connected, and zero capacitance reading can change by a few picofarads whenever the ends of the cable or fixture terminals are physically moved. Always maintain the physical orientation of the leads or terminals after checking for zero capacitance. Subtract zero-capacitance reading from the capacitance reading for the unknown.

Electrolytic capacitors with values greater than 2000μF may require the use of the Ls function to measure their capacitance. Use this conversion equation:

$$Cs = 1/(2\pi f)^2 Ls$$

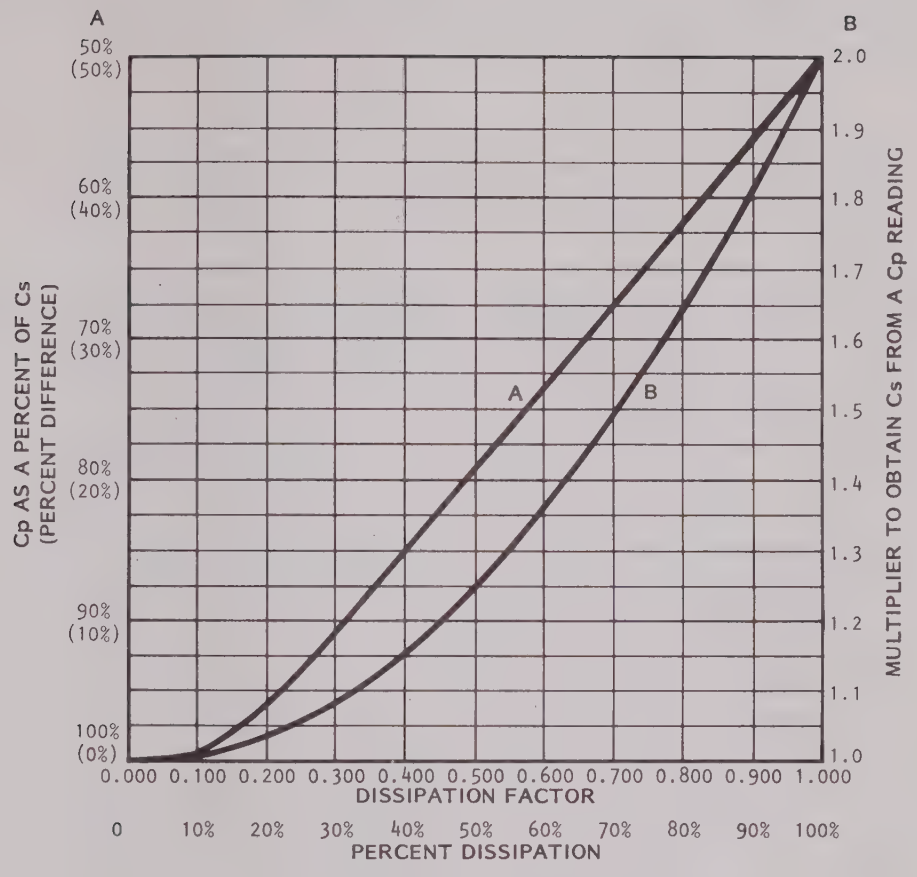
where: f = frequency in hertz, Ls = series inductance in henries and Cs = series capacitance in farads. The meter will read "-Ls" for series capacitance.

Model 253 measures parallel capacitance only. The relation between parallel and series capacitance is:

$$Cs = (1 + D^2)\ Cp \quad \text{where } D = Gp/2\pi fCp$$

The following graph illustrates the relation between Cs and Cp. To use the graph to obtain a Cs value for a capacitor, measure the Cp and D values of the capacitor. Locate the D value on the graph along the horizontal axis. (The D reading from Model 253 will be a dissipation Factor value not a Percent Dissipation value). Move up the graph to the B curve and read the value on the B scale (righthand vertical axis). Multiply the measured Cp value by this reading.

The A curve is used in the same manner as the B curve, but it provides percent difference between Cs and Cp.



2.2.5 Notes on Inductance Measurements

The meter measures the total impedance connected to its terminals. Both the unknown inductor and its leads contribute to this impedance. The leads have some resistance and inductance which affect the value read from the meter.

In making high inductance measurements, avoid ac pickup and keep the stray capacitance to a minimum. To minimize both effects, keep hands as far as possible from the inductor being measured. Keep the leads as short and direct as possible. Take care to avoid coupling stray magnetic fields into the inductor.

For greatest accuracy on low inductance measurements, minimize the lead impedance. Closely spaced, twisted leads will reduce the inductance and pickup of stray fields. The KELVIN KLIPS® Cable Assembly will add about 0.5μH to Ls and 0mΩ to Rs. Short the test leads together and subtract the reading from the unknown inductance measured.

Measuring leakage inductance of transformer windings is an easy task for Model 253 since there are no "false nulls" as found in manually-balanced bridges.

2.2.6 Determining Quality Factor (Q) of Inductors

To determine the Q of inductors, push the D button, record the D reading and calculate Q from the equation Q=1/D. This procedure works well for Q≥Ø.5 (or D≤2). For Q<Ø.5, measure the inductance of the unknown and record the readout display in digits only. With the RANGE switch in the same position, press the R button and note the readout display in digits, only. Do not record the decimal point or range multiplier for Ls or Rs; they are not required. Turn to Figure 2-3 for the D-Q nomograph. With a straightedge, line up the Ls digits recorded (left-hand scale) with the Rs digits recorded (right-hand scale). Q is taken from the left-hand side of the center scale where the straightedge crosses it. For example, with an Ls digital display of "300" and an Rs digital display of "600", Q is Ø.3. Accuracy of Q is primarily limited by interpolation of the nomograph.

Although the nomograph provides a convenient way to approximate Q, it may be determined more accurately by the formula:

$$Q = 2\pi fLs/Rs$$

where f = frequency in hertz (1ØØØHz for Model 253)
π = 3.14
Ls = inductance in henries
Rs = resistance in ohms

See Table 1-1 for accuracy of Ls and Rs measurements.

2.2.7 Determining Dissipation Factor (D) of Capacitors Using Nomograph

Model 253 will measure dissipation factor up to a value of 1.999. For D values greater than 2 the nomograph should be used. Measure the capacitance of the unknown and record the readout display in digits only; do not record decimal point. With the RANGE switch left in the same position, push the G button and note the readout display in digits only; do not record decimal point. Turn to Figure 2-3 for the D-Q nomograph. With a straightedge, line up the Cp digits recorded (left-hand scale) with the Gp digits recorded (right-hand scale). D is taken from the right-hand side of the center scale where the straightedge crosses it. For example, with a Cp digital display of "200" and a Gp digital display of "300", D is 2.3. Accuracy of D is primarily limited by interpolation of the nomograph.

Dissipation factor may be determined more accurately by the formula:

$$D = Gp/2\pi fCp$$

where Gp = Parallel conductance in siemens (mhos)
π = 3.14
f = Frequency in hertz (1ØØØHz for Model 253)
Cp = Parallel capacitance in farads

See Table 1-1 for accuracy of Cp and Gp measurements.

Electrolytic capacitors with high dissipation are usually unstable and the measured values may drift.

2.2.8 Using the Bias Feature

Bias voltage is necessary or desirable when measuring the capacitance of diodes or some electrolytic or tantalum capacitors.

Rear-panel provision is made for connecting an external bias source of zero to 5ØVDC. Remove the shorting link between BIAS terminals when using this feature.

If the external bias supply is not a low ac impedance type, it should have a capacitor bypass of five times the range full scale value connected across the bias terminals. The bias supply should be current limited to Ø.1A maximum.

With no bias supply connected, the rear-panel + and - terminals must be strapped together.

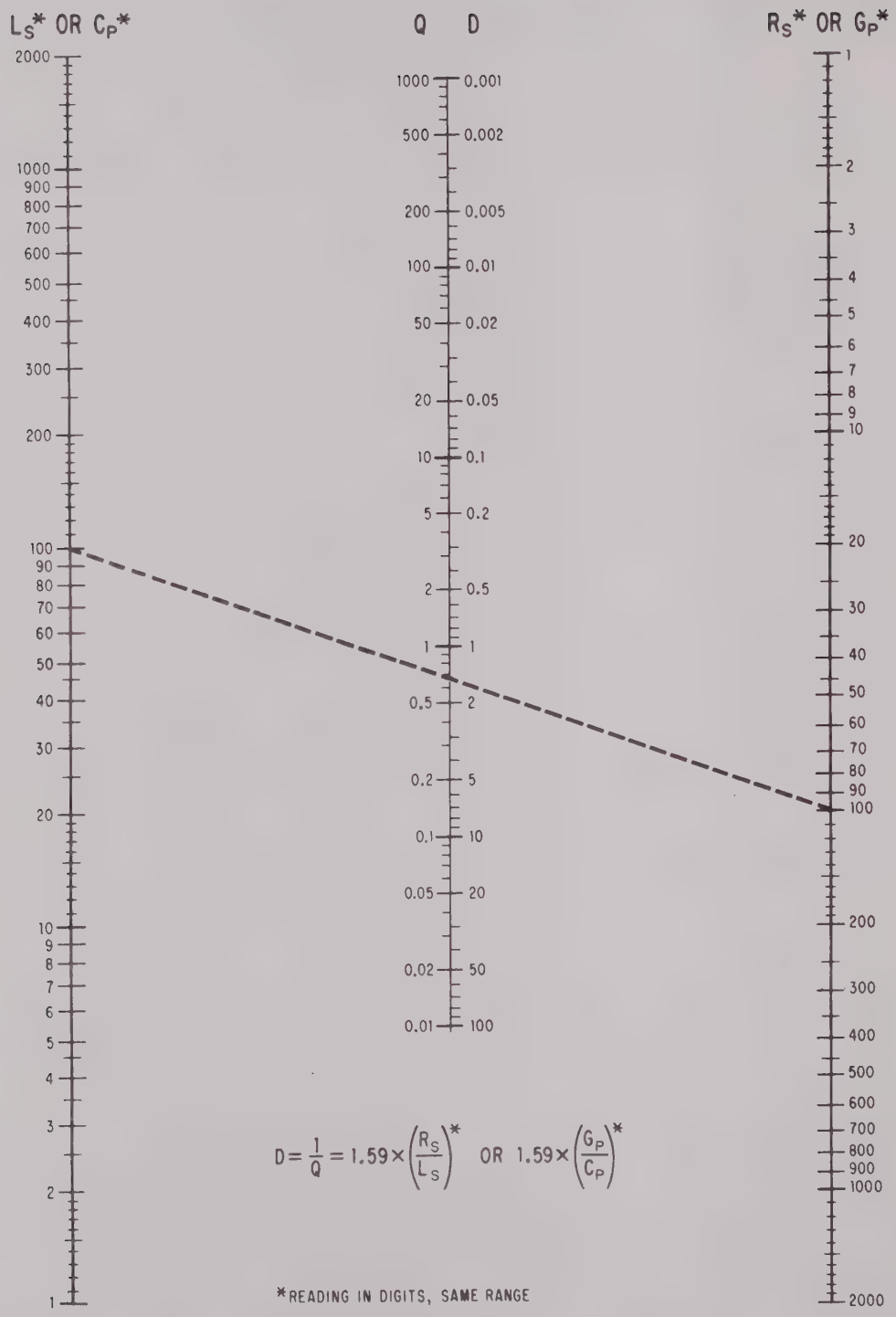


Figure 2-3. Model 253 D-Q Nomograph

SECTION 3
CIRCUIT DESCRIPTIONS

3.1 GENERAL DESCRIPTION

When measuring Cp or Gp, a voltage is applied across the unknown and range resistor in Figure 3-1. The voltage across the unknown is held constant to within one part in several thousand by the 1kHz oscillator feedback control circuit. A current proportional to the value of the unknown impedance is produced through the range resistor. The resultant voltage drop across the range resistor is separated into two vector components by the Phase Sensitive Detectors (PSD) and Reference Voltage Generator (RVG). Receiving gating signals from RVG, the PSD will measure Gp, the component in phase (0°) with RVG, and Cp, the component at quadrature (90°). The selected detector output is then fed to the A/D Converter which has a readout of 1000 counts/volt.

When measuring Ls or Rs, a voltage is applied across the unknown and range resistor in Figure 3-1. The voltage across the range resistor is held constant to within one part in several thousand by the 1kHz oscillator feedback control circuit. With a constant current flowing through the unknown, a voltage proportional to the value of the unknown impedance is developed across the unknown. The resultant voltage drop is separated into two vector components by the Phase Sensitive Detector (PSD) and Reference Voltage Generator (RVG). Receiving gating signals from the RVG, the PSD will measure Rs, the component in phase (0°) with the RVG, and Ls, the component at quadrature (90°). The selected detector output is then fed to the A/D Converter which has a readout of 1000 counts/volt.

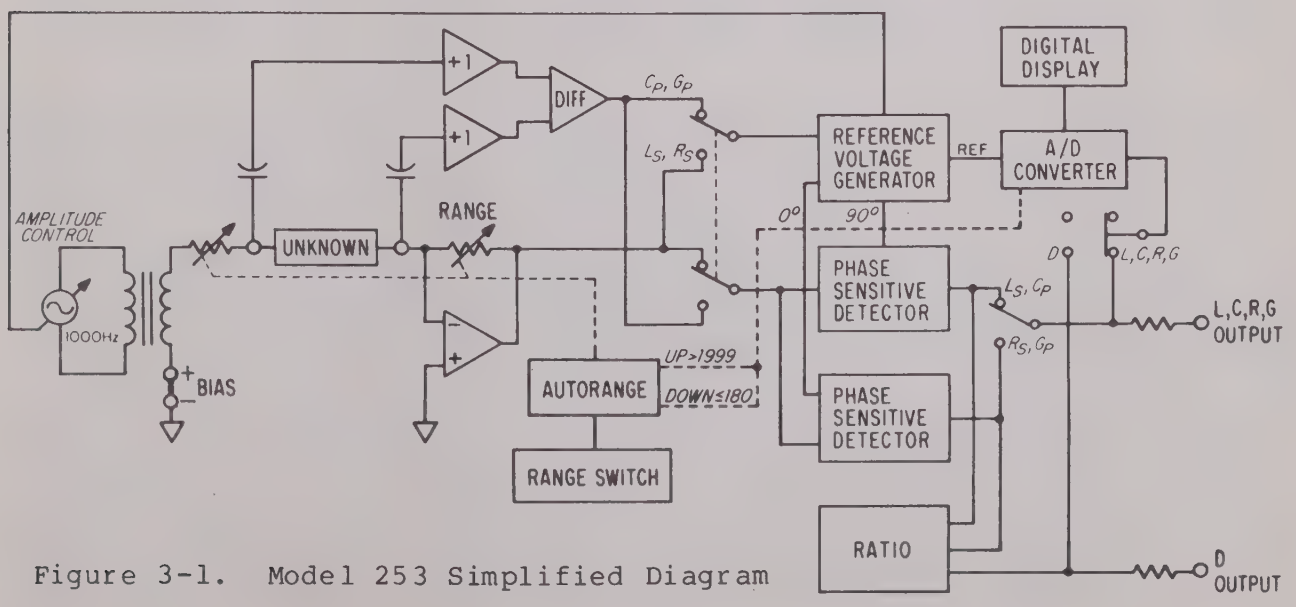


Figure 3-1. Model 253 Simplified Diagram

When measuring the dissipation factor (D) of inductors or capacitors, an analog ratio circuit is used. This circuit compares the loss component (Rs or Gp) to the reactive component (Ls or Cp) and presents a voltage proportional to D to the A/D converter.

Analog output voltages are available at the rear of Model 253 for the selected function (L, C, R or G) and simultaneous D (for L or C unknowns).

3.2 DETAILED CIRCUIT DESCRIPTIONS

In the following description, several conventional resistor networks are involved. To identify which resistor elements are being discussed, the elements are identified by the lower terminal numbers and each is prefixed by a small letter "r". Example: U7 (r1 and r2).

3.2.1 1kHz Oscillator

The 1kHz signal applied to the unknown and range resistor is generated by a power op amp U22, used as a Wien bridge oscillator, with C20, C21 and U19 (r4 and r5) controlling the frequency. Amplitude control for the oscillator is provided by U27 working as a reference voltage null integrator and U35 as the feedback control element. Transformer T2 provides coupling to the unknown and range resistor with provision for inserting bias voltage at rear terminals.

3.2.2 Unknown Differential Amplifier

The voltage drop across the unknown is measured by differential amplifier U3-3. Amplifiers U1-3 and U1-4 act as high impedance ac-coupled buffers to prevent loading the unknown. Resistors U6 (r7 and r8) and U7 (r1 and r2) determine the gain (x1) of U3-3. Trimmer R6 is an adjustment for common-mode voltage rejection. Amplifiers U3-2 and U3-3 are switch (U5) selectable gain stages that provide an overall gain of x1, x10 or x100. Trimmers R11 through R17, switched by U4, provide phase adjustments for each range.

3.2.3 Range Amplifier

The voltage drop across the range resistor (R22, R24 through R27), selected by U12, is measured by amplifier U1-2. Relay K1 switches R22 in series with the unknown for ranges 20Ω and 2Ω (or equivalent). For these ranges U36 is used as a gain amplifier of x1 or x10. Other ranges use U36 as a guard amplifier to reduce the effect of shunt impedances on high value unknowns.

3.2.4 Reference Generator and Phase Sensitive Detector

Reference Generator

A dc voltage proportional to the voltage across the unknown or range resistor is generated by U13-2 and U13-3 used in an operational rectifier circuit. For reactive unknowns, amplifier U13-1 is used as the ac voltage reference input to the operational rectifier. Gating signals for the in-phase and quadrature phase sensitive detectors are produced by U15-3 and U15-4 used as zero crossing detectors. Trimmer R35 is used for adjustment of the 90° reference gate.

Phase Sensitive Detectors

Voltage across the unknown (Rs or Ls) or across the range resistor (Cp or Gp) is measured by two phase sensitive detectors. The in-phase (0°) detector consists of amplifiers U17-1 and U30, together with resistor network U23 and switching gate U20. Ripple filtering is provided by R46, R47, C17 and C18. The quadrature (90°) detector consists of amplifiers U17-4 and U22, together with resistor network U21 and switching gate U20. Ripple filtering is provided by R41, R42, C13, C14 and C15. Trimmer R45 is used to adjust the full scale value of L or C.

3.2.5 Dissipation Factor Circuit

The dissipation factor (D) of inductors or capacitors is derived from the ratio of the loss component (0° phase detector) and reactive component (90° phase detector). This is done with a pulse-width modulator consisting of integrating amplifier U26 and resistor summing network using U28, R60 and R58. The ratio of R (or G) to L (or C) changes the pulse width ratio of the switching amplifier U27 (with switch U24) to produce a null at the integrator input. Comparator U15-2 acts as the switch driver and is frequency set by the test frequency of the instrument. Amplifiers U27-1 and U27-3 together with switch U24 are the demodulator which produces an analog voltage proportional to the pulse width variation and scaled to equal the dissipation factor. Trimmer R52 adjusts full scale D value.

3.2.6 Overload Blanking Circuit

U15-1 is a comparator amplifier. It monitors the signal levels of the phase detector input and the level regulator amplifier U27-4. When either level exceeds its limit, comparator U15 goes low. This output is combined with a digital overrange signal at the input of a NAND gate of U29 to provide a display blanking output.

3.2.7 Analog to Digital Converter

The A/D converter resides in U31 (MC14433) which is a CMOS dual-slope integrating converter. This circuit provides a multiplexed output which is decoded and displayed by a plug-in circuit assembly (42916).

3.2.8 Function and Range Programming

A bipolar PROM (U33) stores the necessary range and function programming information for Model 253. The stored program has 32 addresses each with 8 bits of data. These addresses are reached by 2 function bits and 3 range bits which are set by the front panel switches.

3.2.9 Autorange Circuit

The range programming PROM is interfaced to the range switch with a presettable counter U3 (Assy 43407). In the non-autorange positions the counter is in a preset mode and the PROM addressing follows the bit information of the switch. In the AUTO position, the counter takes information from the A/D converter. If the display exceeds 1999, the counter up-ranges and if the display is 180 or less, it down-ranges.

SECTION 4
MAINTENANCE

4.1 CALIBRATION PROCEDURE

Although Model 253 is an inherently stable instrument, good maintenance practices suggest that it be calibrated every six months; more often if used in extreme environments or if inaccurate readings are suspected.

Equipment Required	Minimum Specifications
Frequency Counter	Measure 1000Hz with resolution of 1Hz
Digital Voltmeter	Resolution of 100μVDC
Resistance Standard	1000Ω ±0.05%, non-inductive such as ESI Model SR 1.
Capacitance Standard	100nF, ±0.05%, silvered mica or polystyrene
Dissipation Factor Standards	1μF Decade Capacitor, 5 dial, polystyrene, D<0.0002; 10μF polystyrene capacitor with D known to ±0.001; 100μF capacitor with D known to ±0.001
KELVIN KLIPS® Four-Terminal Clips	ESI Part No. 43157

Refer to Figure 4-1 for adjustment locations.

4.1.1 Power Supply Check

1. Setup - Turn on instrument and allow ten minute warm-up period; then remove cover. Check - Power supply voltages at C44 and C45 should be + and -5V ±5% (4.75V to 5.25V). Use rear panel COM terminal for voltmeter low input.

4.1.2 Oscillator Adjust

1. Setup - Press R function button. Set RANGE switch to 3 (2000Ω), and short unknown test leads together. Connect voltmeter high

input to Test Socket (TS) pin (2) and frequency counter input to TS (1). Use rear panel COM terminal for circuit common. Adjustment - Set trimmer S for DVM reading of ØV (±Ø.2V). Counter reading should be 1ØØØHz (±1ØHz).

4.1.3 L, C, R, G Alignment

1. R, G PHASE DETECTOR ZERO TRIM. Setup - Press R function button and set RANGE switch to 3 (2ØØØΩ). Short unknown test leads together. Connect DVM input to TS (6). Adjustment - Set trimmer P for +Ø.3mV ±Ø.1mV on DVM.

2. UNKNOWN AMP COMMON MODE TRIM. Setup - Press R function button and set RANGE to Ø (2Ω). Short unknown test leads together (keep movable jaws adjacent). Adjustment - Adjust trimmer J for DVM reading of ØV ±Ø.3mV at TS (6).

3. L, C PHASE DETECTOR ZERO TRIM. Setup - Press L function button and set RANGE switch to 3 (2ØØmH). Short unknown test leads together and connect DVM input to TS (5). Adjustment - Set trimmer M for +Ø.3mV ±Ø.1mV on DVM.

4. L, C, R, G OUTPUT AMP ZERO TRIM. Setup - Same as step 3 except connect DVM input to TS (4). Adjustment - Set trimmer V for ØV ±Ø.3mV on DVM.

5. UNKNOWN AND RANGE AMP PHASE TRIM. Setup - Press C function button and set RANGE switch to 3 (2ØØnF). Connect decade capacitor to unknown test leads and set at 16ØnF (±5%). Adjustment - Note voltage at TS (6) and then push L function button, again noting TS (6) voltage. The two should be equal (±Ø.3mV). If not, adjust trimmer X until they are. Next adjust trimmer D for ØV ±Ø.3mV output at TS (6) for both L and C functions.

6. QUADRATURE GATE PHASE TRIM. Setup - Press R function button and set RANGE switch to 3 (2ØØØΩ). Connect 1ØØØΩ (±Ø.Ø5%) standard to unknown test leads. Adjustment - Set trimmer L for DVM reading of ØV ±Ø.3mV at TS (5).

7. R, G FULL SCALE TRIM. Setup - Same as step 6. Adjustment - Set trimmer K for front panel digital reading of 1ØØØ. With DVM, read voltage at TS (4) and adjust trimmer R for +1.ØV (±Ø.5mV).

8. L, C FULL SCALE TRIM. Setup - Press C function button and set RANGE switch to 3 (2ØØnF). Connect 1ØØnF (±Ø.Ø5%) standard to unknown test leads. Adjustment - Set trimmer N for front panel reading of 1ØØØ.

4.1.4 Dissipation Factor (D) Alignment

1. LOW LEVEL ZERO TRIM. Setup - Press C function button and set RANGE switch to 3 (200nF). Connect a low loss (D<Ø.ØØØ2) decade capacitor to unknown test leads. Adjustment - Set the decade capacitor to 105nF and, with a DVM, note the voltage at TS (3) or D output terminal at the rear panel. Set the decade to 5nF and again note the voltage. If the two voltages are not equal (±1mV), adjust trimmer W until switching between 105nF and 5nF produces equal readings.

2. HIGH LEVEL ZERO TRIM. Setup - Same as step 1. Adjustment - Set decade capacitor to 100nF and adjust trimmer U until voltage at TS (3) or D output is ØV ±Ø.3mV.

3. D FULL SCALE TRIM. Setup - Same as step 1. Adjustment - Set the decade capacitor for a front panel C reading of 159.2nF. Connect the 1000Ω standard resistor in parallel with the decade capacitor. Set trimmer T for a front panel D reading (push D button) of 1.000.

   NOTE: The following trim adjustments set D=Ø for all C ranges except 200nF, which was adjusted in step 5 of Paragraph 4.1.3.

4. 200pF RANGE D TRIM. Setup - Press C function button and set RANGE switch to Ø (200pF). Connect the low loss (D<Ø.ØØØ2) decade capacitor to unknown test leads. Adjustment - Set the decade to 100pF (±20%) and adjust trimmer H for ØV ±Ø.3mV at TS (3), or D output.

5. 2nF RANGE D TRIM. Setup - Same as step 4, except set RANGE switch to 1 (2nF). Adjustment - Set decade to 1nF (±20%) and adjust trimmer F for ØV ±Ø.3mV at TS (3), or D output.

6. 20nF RANGE D TRIM. Setup - Same as step 4, except set RANGE switch to 2 (20nF). Adjustment - Set decade to 10nF (±20%) and adjust trimmer E for ØV ±Ø.3mV at TS (3), or D output.

7. 2μF RANGE D TRIM. Setup - Same as step 4, except set RANGE switch to 4 (2μF). Adjustment - Set decade to 1μF (±20%) and adjust trimmer C for ØV ±Ø.3mV at TS (3), or D output.

8. 20μF RANGE D TRIM. Setup - Set RANGE switch to 5 (20μF) and connect a 10μF (±20%) capacitor (D known to ±Ø.ØØ1) to unknown test leads. Adjustment - Adjust trimmer B for front panel D reading (push D button) equal to D value of the 10μF capacitor.

9. 200μF RANGE D TRIM. Setup - Set RANGE switch to 6 (200μF) and connect a 100μF (±20%) capacitor (D known to ±Ø.ØØ1) to unknown test leads. Adjustment - Adjust trimmer A for front panel D reading (push D button) equal to D value of the 100μF capacitor.

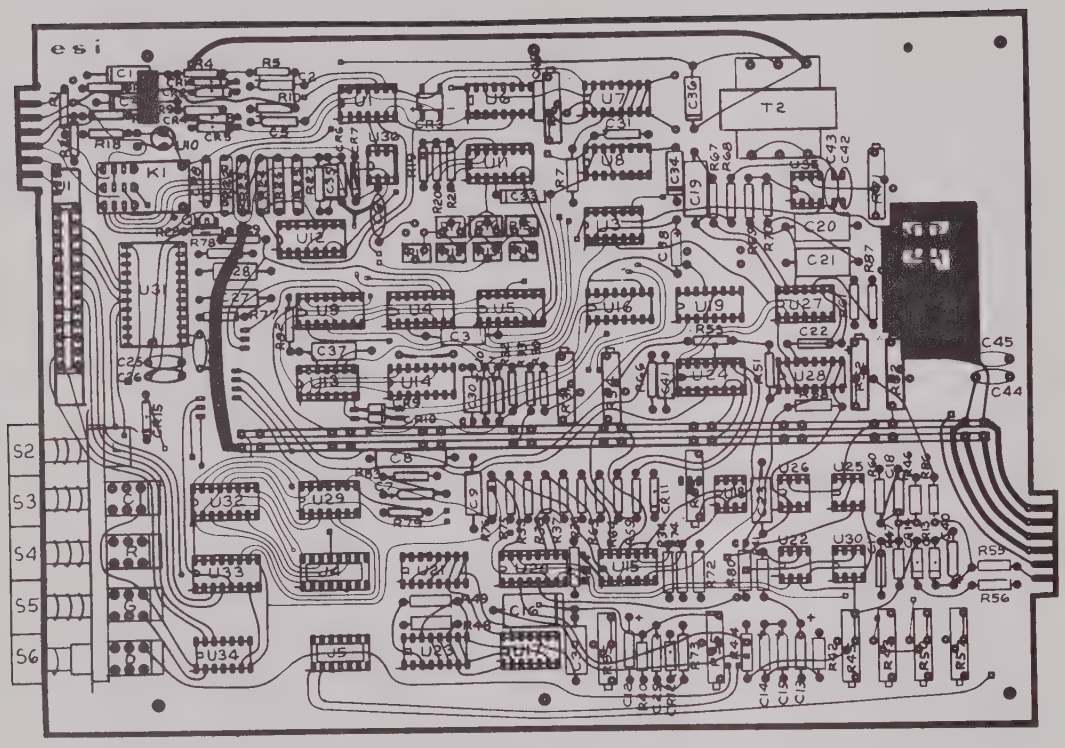


Figure 4-1.

SECTION 5

PARTS LISTS AND DIAGRAMS

5.1 MAINFRAME PARTS (30253)

DESCRIPTION	ESI PART NO.	SEE FIGURE NO.
Assembly, Back Panel (includes	43157	5-5
Circuit Assembly, Power Supply)	(42903)	(5-6)
Assembly, Cable, Auto Range Control	43766	
Assembly, Cable, KELVIN KLIPS®	43072	
Assembly, Range Switch	43721	
P1 Header, 16 Pin, DIP	20799	
S1 Switch, Range	43654	
Circuit Assembly, Auto Range	43407	5-4
Circuit Assembly, Display	43668	5-3
Circuit Assembly, Motherboard	43064	5-1, 5-2
Cover, Chassis	42988	
Display Window, Acrylic	43116	
Foot, Rubber	08739	
Frame, Front Panel	43068	
Front Panel Overlay	43431	
Handle, Kit	43088	
Instruction Manual	43761	
Knob, Range Switch	22593	
Pushrod, Power Switch	43143	

Options:

Front Panel Dust Cover	43374
Sorting Fixture	Model 2001
Sorting Fixture Cable Assembly (4BNC)	43586

5.2 MOTHERBOARD CIRCUIT ASSEMBLY (Part No. 43064)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1, C4	Capacitor, 0.047μF, 200V, Mylar	12239
C2, C5, C13 C17, C18, C22, C29	Capacitor, 1μF, 35V, Tant	06472
C3, C37, C39	Capacitor, 1000pF, 500V, Poly	07094
C6	Capacitor, 3.3pF, 1kV, Disc	01925
C7, C12	Capacitor, 6.8μF, 35V, Tant	25339
C8	Capacitor, 2000pF, 500V Mica	02158
C9, C19, C23, C27, C28	Capacitor, 0.1μF, 200V, Mylar	12121
C10, C11, C14, C15, C31, C38, C40	Capacitor, 2.2μF, 20V, Tant	13283
C16	Capacitor, 0.33μF, 200V, Mylar	12446
C20, C21	Capacitor, 0.0159μF, 1%, 100V	18845
C24-C26, C42-C45	Capacitor, 0.05μF, 50V, Disc	12116
C30	Capacitor, 390pF, 600V, Poly	29299
C33	Capacitor, 0.01μF, 100V, Mylar	12260
C34	Capacitor, 0.0033μF, 100V, Mylar	20879
C35	Capacitor, 91pF, 2%, 600V Silver Mica	43738
C36	Capacitor, 0.0022μF, 100V, Mylar	12399
C41	Capacitor, 220pF, 600V, Poly	29297
C46	Capacitor, 560pF, 600V, Poly	25922
CR1, CR2, CR4, CR5 CR9-CR12, CR15	Diode, 1N914	12356
CR3	Diode Bridge, Mini DIP	26339
CR6-CR8	Diode, 1N4005	01779
CR13, CR14	Diode, 1N4732, Zener	12449
J1	Connector, 24 pin, PC	43081
K1	Relay, 12V, 4PDT, PC MT	43083
Q1	Transistor, 2N3702	12041
R1-R3, R8, R29, R32, R41, R46, R56, R87	Resistor, 1kΩ, 10%, 1/4W	13920
R4, R5, R9, R10 R18, R68, R70	Resistor, 100kΩ, 10%, 1/4W	13945
R6	Resistor, Trimpot, 200Ω, 15 Turn	12083
R7	Resistor, 30.1kΩ, 1%, 1/8W	43082
R11-R17	Resistor, Trimpot, 100kΩ, 1 Turn	43092
R19	Resistor, 18kΩ, 10%, 1/4W	13936
R20, R28	Resistor, 2.2kΩ, 10%, 1/4W	13924
R21	Resistor, 220Ω, 10%, 1/4W	13911
R22	Resistor, 1.001Ω, ESI, QB, 4T	43302
R23, R25	Resistor, 1kΩ, ESI, QB	24940
R24	Resistor, 100Ω, 0.02%, ESI, QB	24939
R26	Resistor, 10kΩ, ESI, QB	24941
R27	Resistor, 100kΩ, 0.1%, MF	43300
R30	Resistor, 1.8kΩ, 10%, 1/4W	13923

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
R31, R35, R65	Resistor, Trimpot, 1kΩ, 15 Turn	18469
R33	Resistor, 33Ω, 10%, 1/4W	43301
R34	Resistor, 3.32kΩ, 1%, 1/8W	21771
R36-R40, R79	Resistor, 10kΩ, 10%, 1/4W	13933
R42, R47	Resistor, 68Ω, 10%, 1/4W	13902
R43, R45, R50, R85	Resistor, Trimpot, 10kΩ, 15 Turn	20145
R44	Resistor, 11kΩ, 1%, 1/4W	13359
R48, R49	Resistor, 90.9kΩ, 1%, 1/4W	24557
R51, R58	Resistor, 100kΩ, 1%, 1/4W	21750
R52	Resistor, Trimpot, 2kΩ, 15 Turn	12084
R53	Resistor, 2.2MΩ, 10%, 1/4W	13962
R54, R62	Resistor, Trimpot, 100kΩ, 15 Turn	21455
R55, R86	Resistor, 470Ω, 10%, 1/4W	13915
R57	Resistor, Trimpot, 20kΩ, 15 Turn	21199
R59, R75, R76	Resistor, 22kΩ, 10%, 1/4W	13937
R60, R84	Resistor, 4.99kΩ, 1%, 1/4W	21737
R61, R77	Resistor, 470kΩ, 10%, 1/4W	13955
R63, R64	Resistor, 4.7kΩ, 10%, 1/4W	13927
R66, R80	Resistor, 2kΩ, 1%, 1/4W	21733
R67	Resistor, 82kΩ, 10%, 1/4W	24812
R69	Resistor, 100Ω, 10%, 1/4W	13907
R71	Resistor, Trimpot, 500Ω, 15 Turn	12093
R72	Resistor, 20kΩ, 1%, 1/4W	21743
R73	Resistor, 31.6kΩ, 1%, 1/4W	21745
R74	Resistor, 63.4kΩ, 1%, 1/4W	21718
R78	Resistor, 316kΩ, 1%, 1/4W	21755
R82	Resistor, 10kΩ, 1%, 1/8W, MF	21740
R83	Resistor, 402kΩ, 1%, 1/8W, MF	21756
S2-S6	Switch, 5 Station, Pushbutton	42882
T2	Transformer, Coupling	42964
U1, U3, U13, U17	IC, 3403	40840
U2	IC, 759	43098
U4	IC, 4051	40841
U5, U9, U20, U24	IC, 4053	20744
U6, U8	Resistor Network, 1kΩ, 0.5%, 8 Resistors	43117
U7, U14, U16, U19, U21, U23, U28	Resistor Network, 10kΩ, 0.5%, 8 Resistors	43077
U10	LED Isolator, CLM 6000	25940
U11, U12	IC, 4052	20743
U15	IC, 339	40849
U18	IC, Precision 2.5V REF, 1403	43099
U22, U30	IC, 741	20668
U25, U36	IC, 356H	41473
U26	IC, 741K	21625
U27	IC, TL074	43299
U29	IC, 4012	43086
U31	IC, 14433	43067

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
U32	IC, 4049	41305
U33	IC, 6331N	43104
U34	Resistor Network, 22kΩ, 13 Res	20712
U35	IC, 3080	20723
	PC Board, Motherboard	43063
	Socket, 8 Pin, DIP for U18, U22, U25, U26, U30, U35 and U36	22410
	Socket, 14 Pin, DIP for J5, U1, U3, U13, U15, U17, U27 and U29	19189
	Socket, 16 Pin, DIP for J4,U4,U5, U9,U11,U12,U20,U24,U32 and U33	20860
	Socket, 24 Pin, DIP for U31	41492

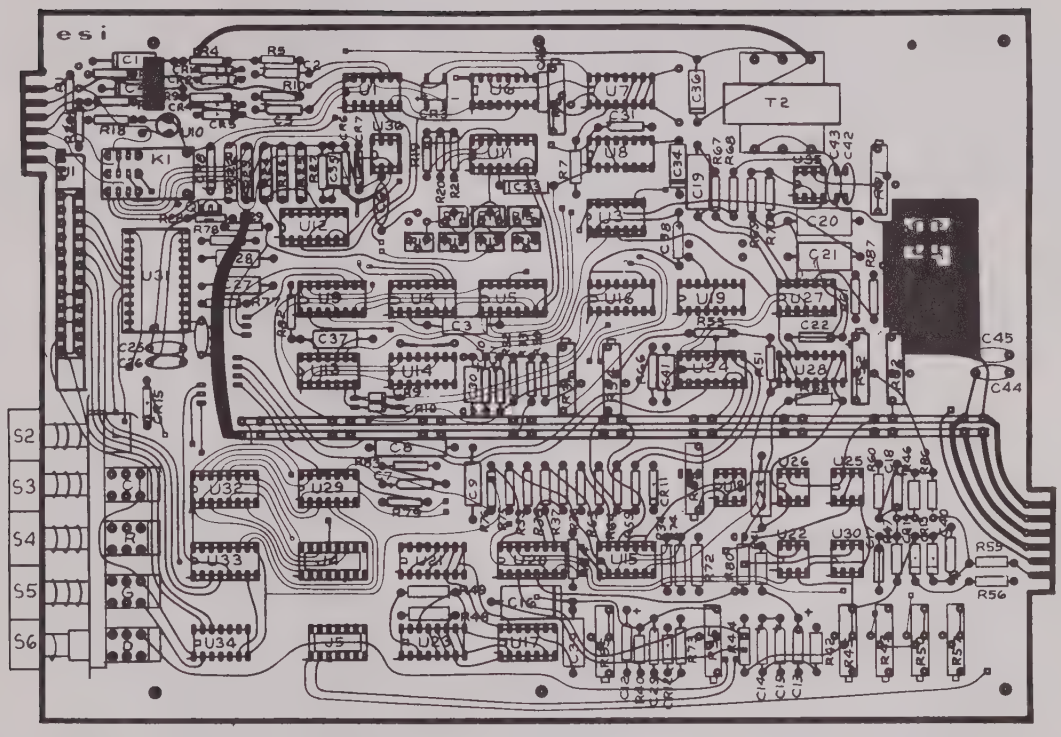
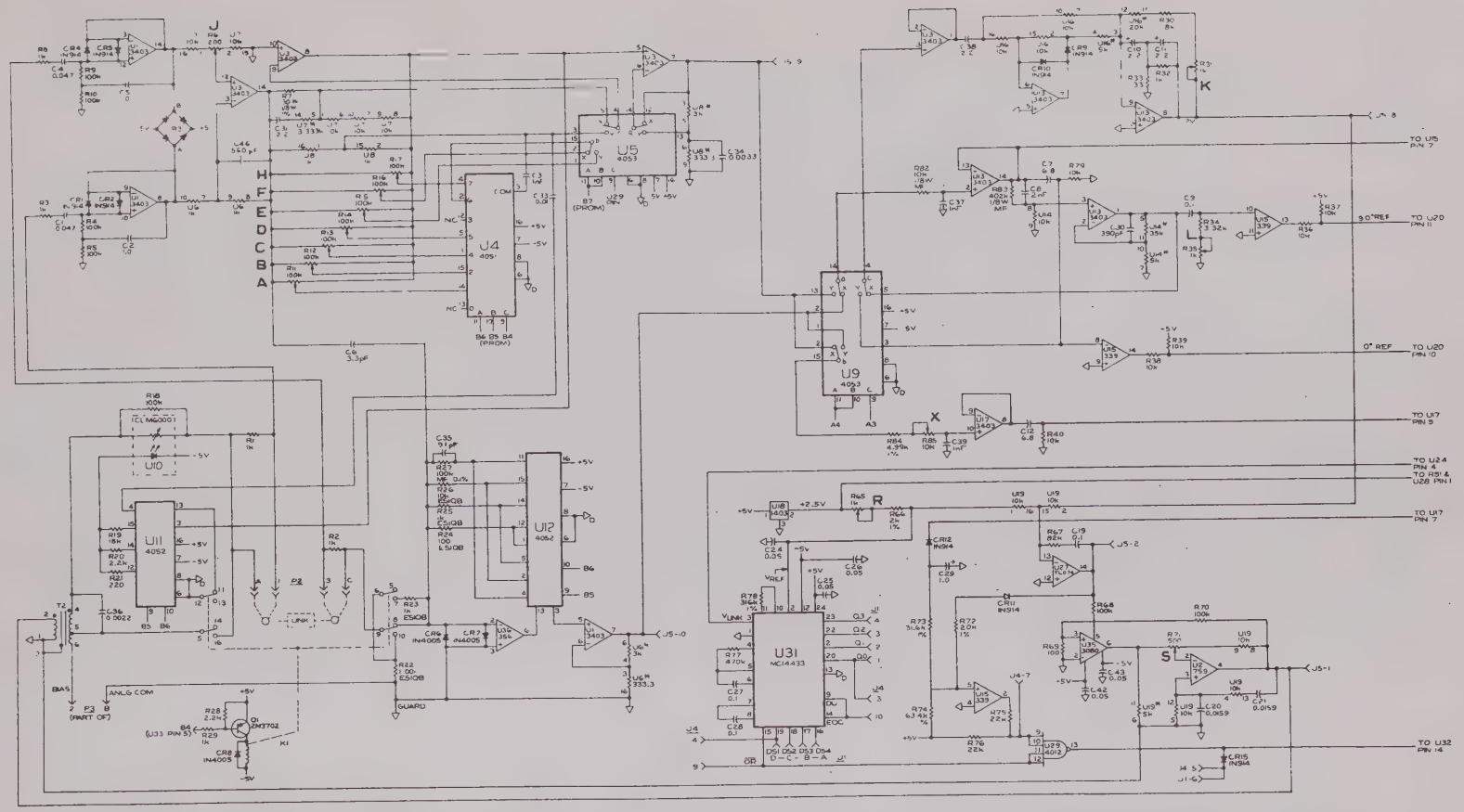


Figure 5-1. Motherboard


U1
U2
U3
U4
U5
U6
U7
U8
U9
U10
U11
U12
U13
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U69
U70

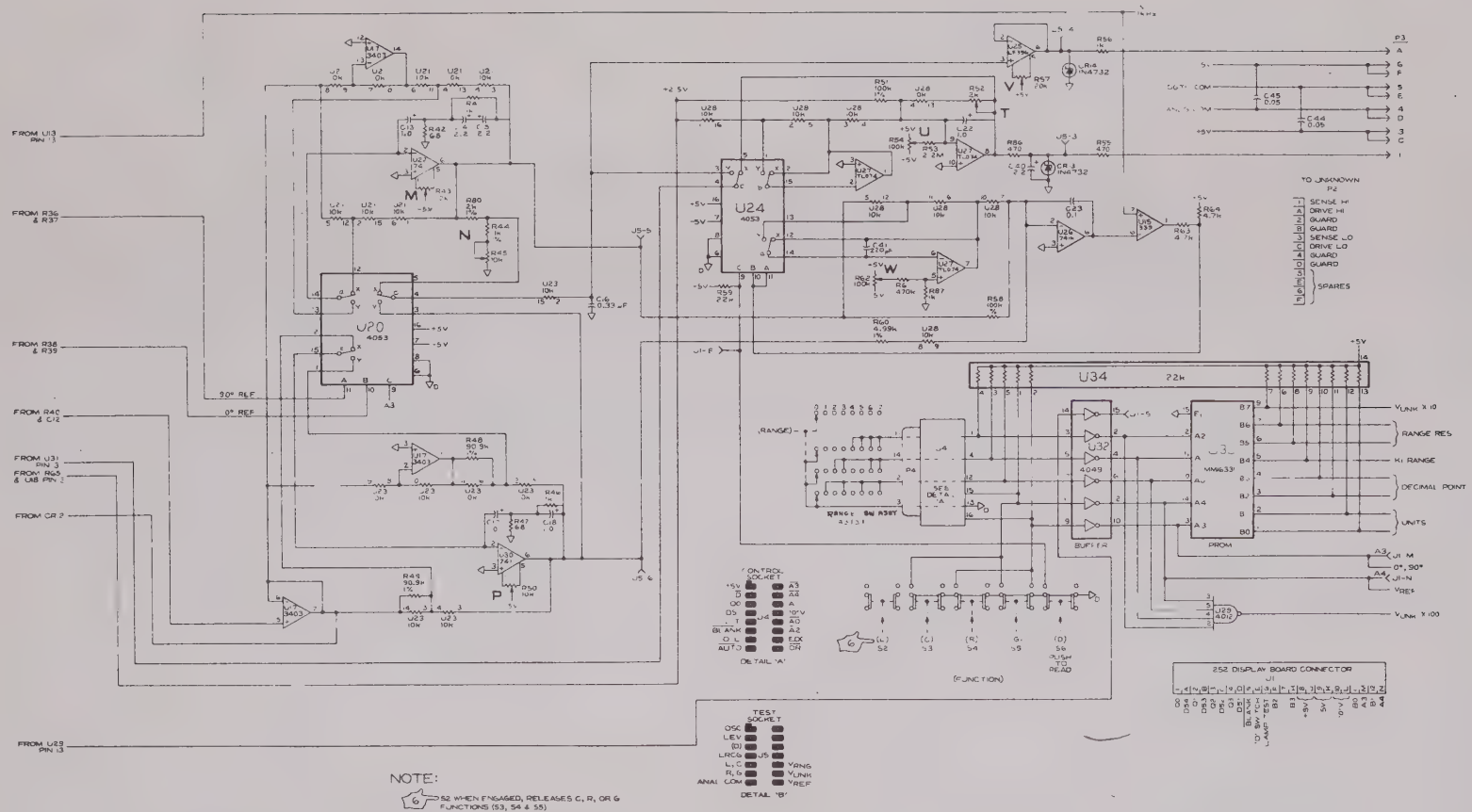
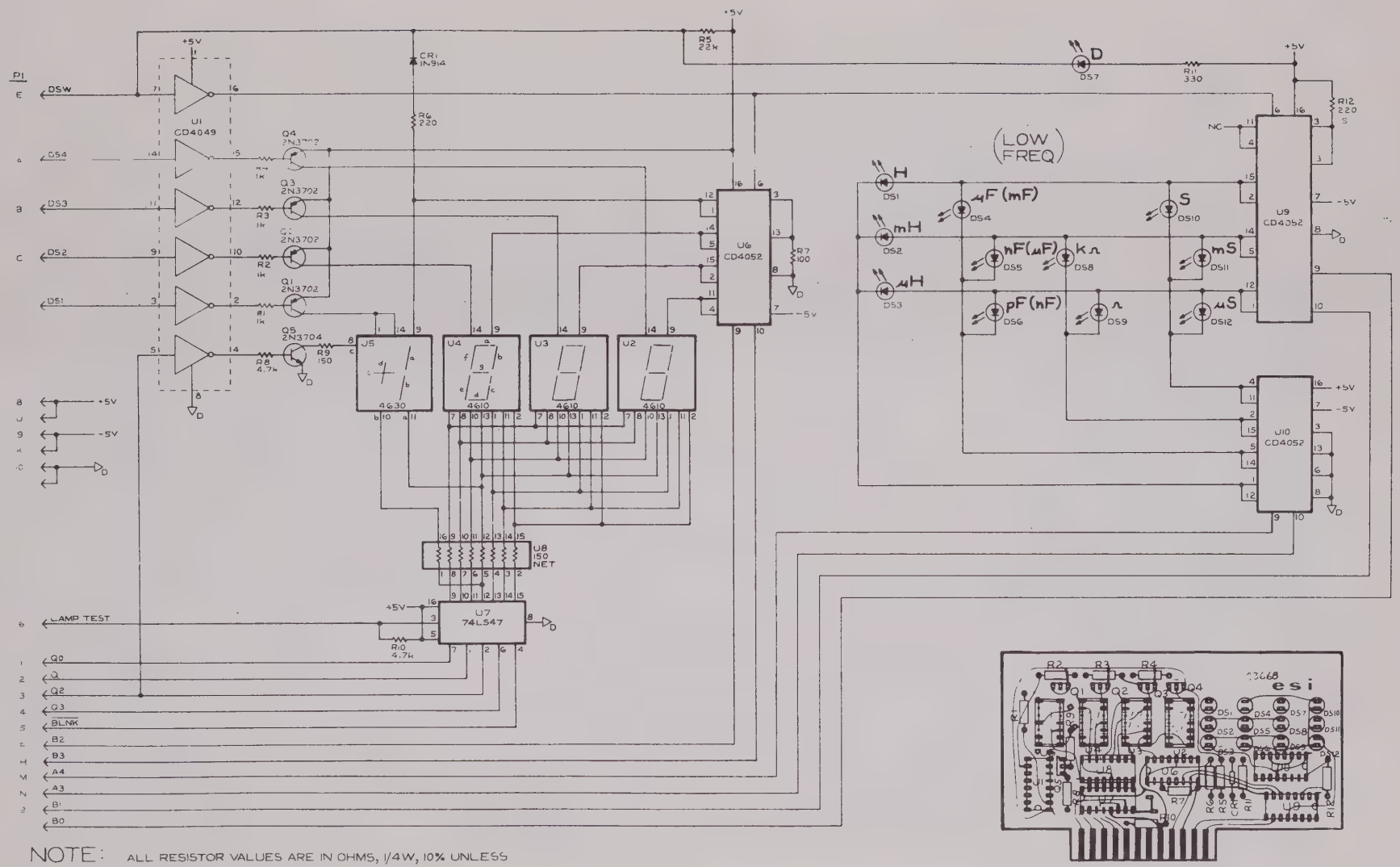


Figure 5-2. Motherboard Circuit (Continued)

5.3 DISPLAY CIRCUIT ASSEMBLY (Part No. 43668)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
CR1	Diode, IN914	12356
DS1-DS12	LED, Red	26021
Q1-Q4	Transistor, 2N3702	12041
Q5	Transistor, 2N3704	12077
R1-R4	Resistor, 1kΩ, ±10%, 1/4W	13920
R5	Resistor, 22kΩ,±10%, 1/4W	13937
R6, R12	Resistor,220Ω, ±5%, 1/4W	13911
R7	Resistor, 100Ω, ±10%, 1/4W	13907
R8, R10	Resistor, 4.7kΩ, ±10%, 1/4W	13927
R9	Resistor, 150Ω, ±10%, 1/4W	13909
U1	IC, 4049	41305
U2-U4	IC, 4610, 7 Segment Display LED	41350
U5	IC, 4630, ±1 Display LED	41349
U6,U9,U10	IC, 4052	20743
U7	IC, 74LS47	43078
U8	Resistor Network, 150Ω	43080
	PC Board, Display	42915
	Socket, 14 Pin, DIP for U2-U5	19189

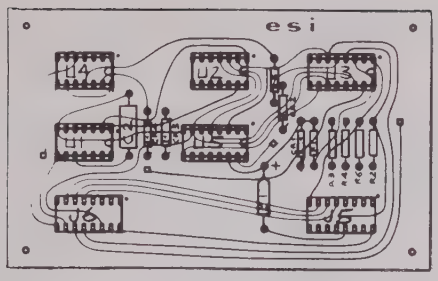


NOTE: ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.

Figure 5-3. Display Circuit Assembly

5.4 AUTORANGE CIRCUIT ASSEMBLY (Part No. 43407)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
CR1-CR4	Diode, IN914A	12356
C1	Capacitor, 2.2μF, 20V, Tantalum	13283
C2	Capacitor, 100pF, 500V, Poly	07094
R1	Resistor, 470kΩ, ±10%, 1/4W	13955
R2-R4,R6	Resistor, 22kΩ, ±10%, 1/4W	13937
R5	Resistor, 15kΩ, ±10%, 1/4W	13935
U1	IC, 4011	20725
U2	IC, 4012	43086
U3	IC, 4029	40843
U4	IC, 4030	40844
U5	IC, 4049	41305
	PC Board, Autorange	43406
	Socket, 14 Pin, DIP for U1, U2 and U4	19189
	Socket, 16 Pin, DIP for U3, U5, J5 and U6	20860



IC POWER			
CKT REF	5V	0V	NC
U5	1	8	13,16
U3	16	8	
U2	14	7	6,8
U1, U4	14	7	

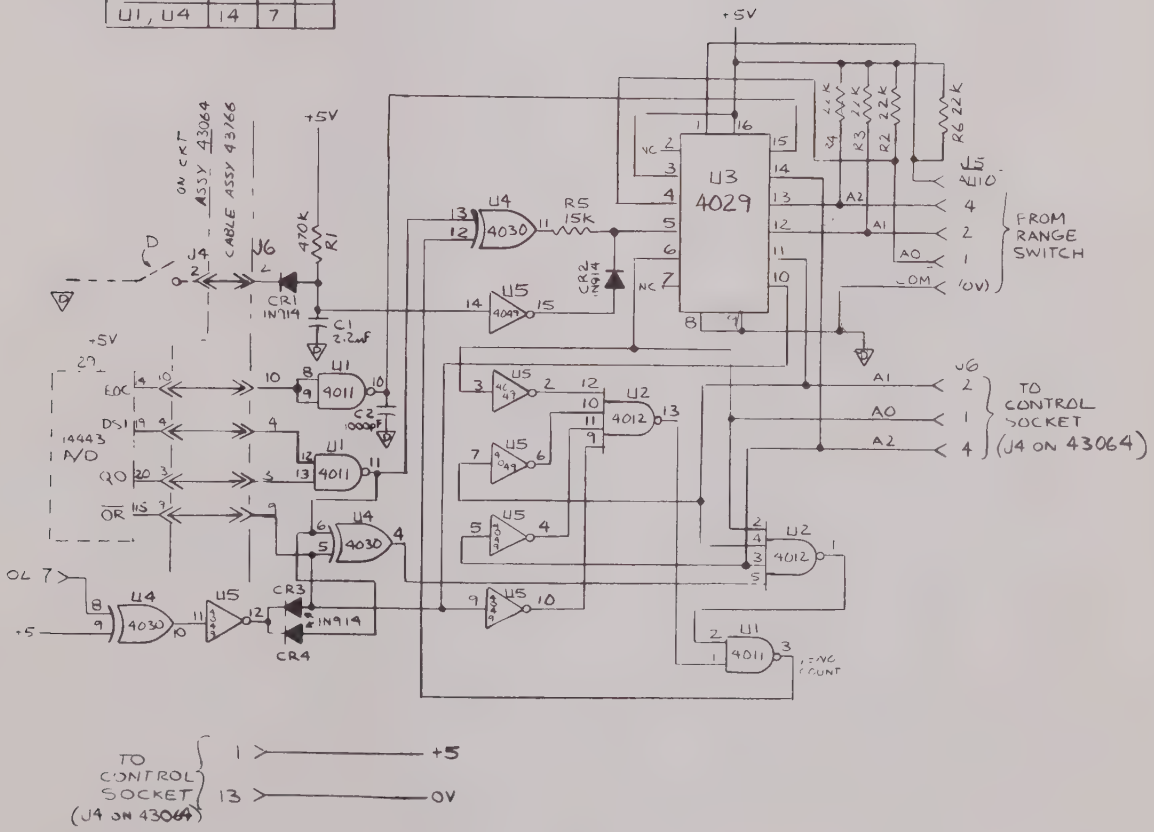
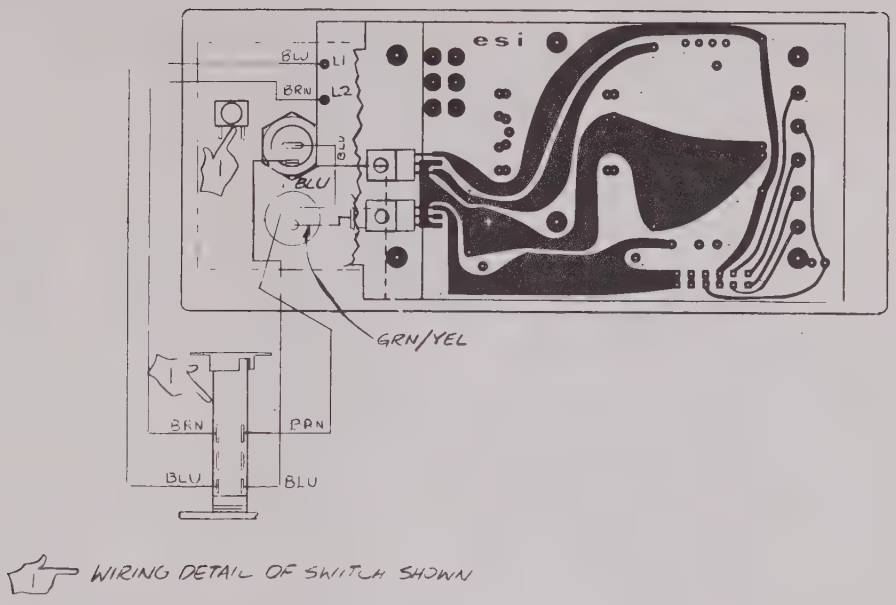


Figure 5-4. Autorange Circuit Assembly

5.5 REAR PANEL ASSEMBLY (Part No. 43157)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
F1	Fuse	08952
S1	Power Switch	23164
U1	Voltage Regulator, 7805	20699
U2	Voltage Regulator, LM320T-5	41876
	Back Panel	42986
	Ckt Assy, Power Supply	42903
	Bracket, Instrument Cord Wrap	43768
	Bracket, Switch Support	43052
	Wrap, Switch Support	43138
	Fuse Holder	03074
	Power Cord	24077



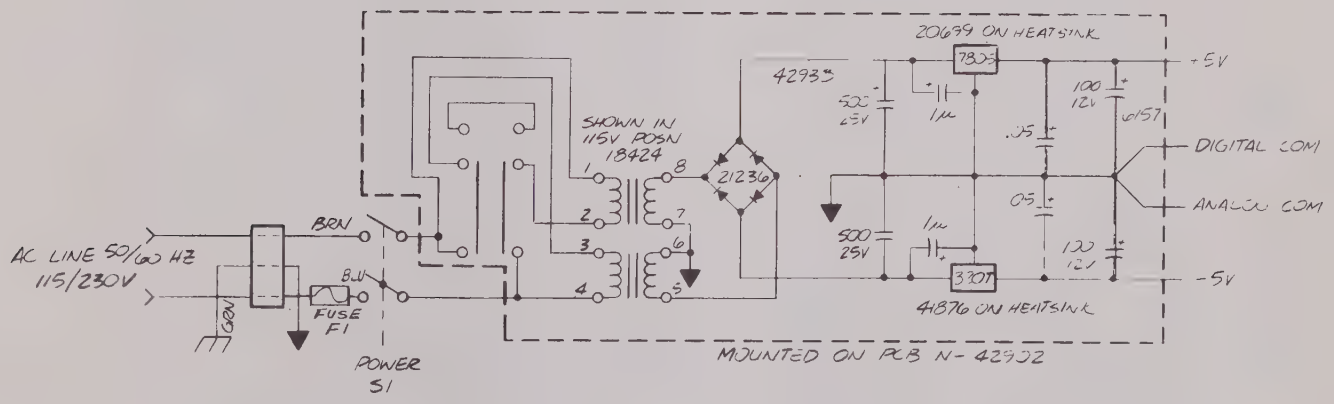
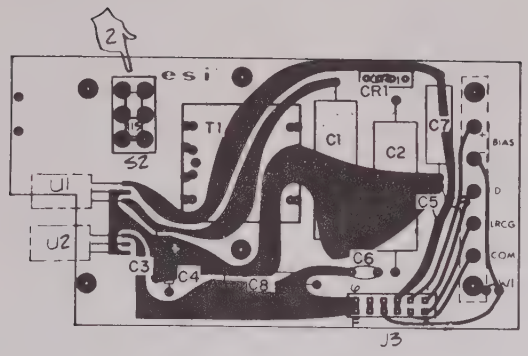


Figure 5-5. Rear Panel Assembly

5.6 POWER SUPPLY CIRCUIT ASSEMBLY (Part No. 42903)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1, C2	Capacitor, 500μF, 25V	42938
C3, C4	Capacitor, 1μF, Tantalum	06472
C5, C6	Capacitor, 0.05μF, Disc	12116
C7, C8	Capacitor, 100μF, 12V	06157
CR1	Bridge, Full Wave	21236
J3	Connector, 6 Position	43101
S2	Switch, Slide (230/115V)	29233
T1	Transformer	43303
TB1	Barrier Strip, 5 Position	43079
W1	Wire, No. 20 Copper	
	PC Board, Power Supply	42902
	Shorting Strap	43308



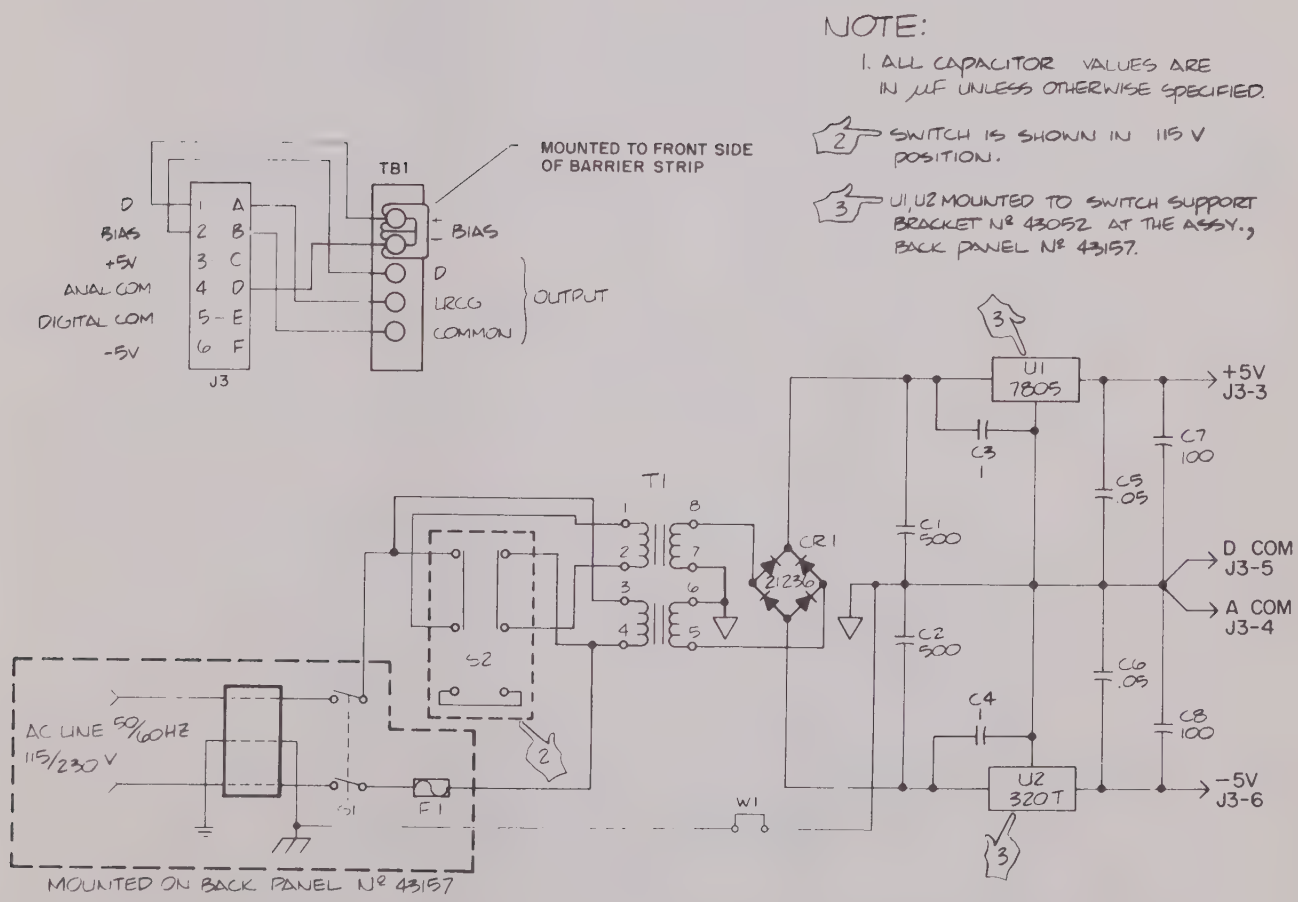


Figure 5-6. Power Supply

MODEL 252, 253, 254 ADDENDUM

MEASURING GROUNDED UNKNOWNS

ESI Models 252, 253 and 254 low cost LRC meters are designed to measure ungrounded components. However, with a minor modification they can be used to measure impedances that are connected directly or tightly coupled to earth ground.

This first procedure outlines the modification of all instruments with serial numbers 928999 and smaller.

1. Remove all instrument power.

2. Remove instrument cover by unscrewing the two cover screws and sliding the cover off.

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

3. Locate the Power Supply circuit assembly, Part No. 53157. (Attached to the rear panel.)

4. Remove jumper wire W1 from this assembly (see Figure 1).

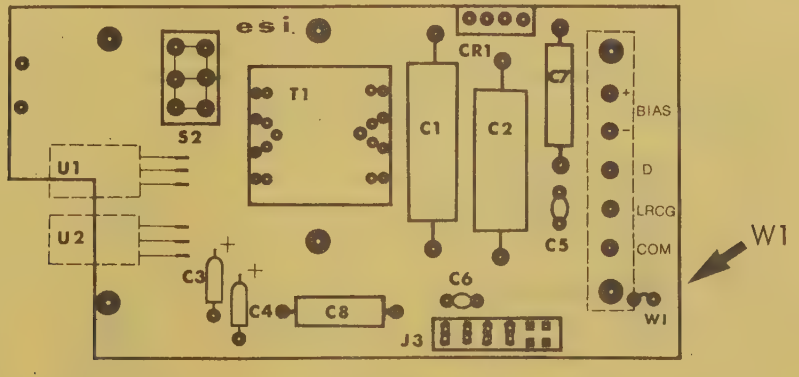


Figure 1.

5. Locate the Range Switch on the front panel.

6. Unsolder and isolate the solder lug from the Range Switch making sure the black wire remains attached to the switch terminal (see Figure 2).

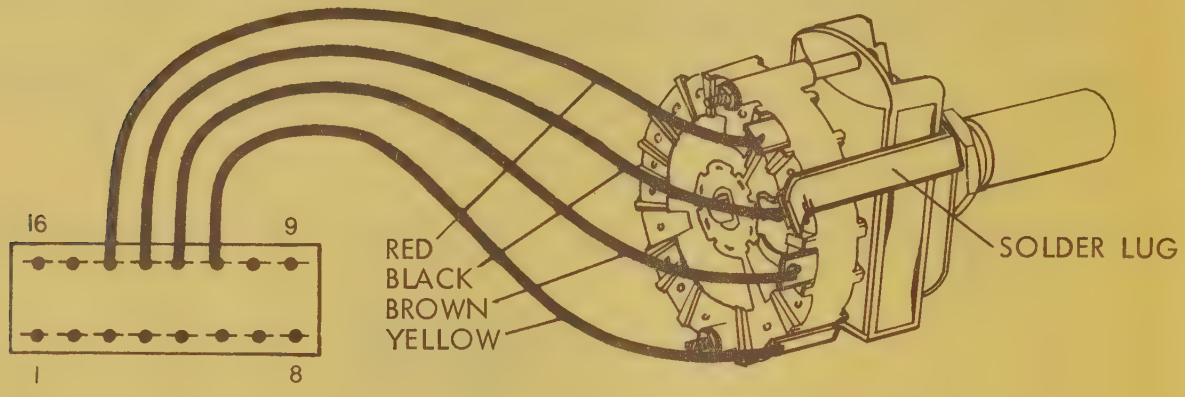


Figure 2.

7. Replace instrument cover.

The modification of instruments with serial numbers 929000 and greater is as follows:

1. Locate the connector strip on the rear panel (see Figure 3).

2. Remove and isolate the spade lug from the terminal marked COM.

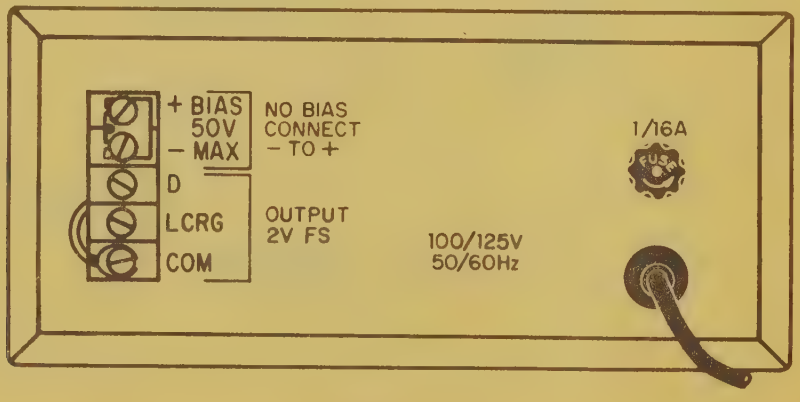


Figure 3.

To make measurements of grounded unknowns, connect the grounded side of the unknown to the KELVIN KLIPS® with the red insulating hinge-spool and the ungrounded end to the clip with the black spool (see Figure 4).

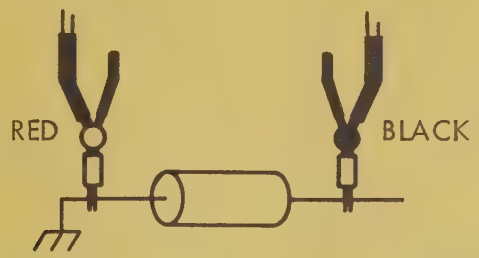


Figure 4.

During low value, grounded capacitance measurements a small zero offset may become apparent. This offset can be corrected by making a reading with the unknown connected to the red clips only and subtracting it from the final measured capacitance.

To return to normal ungrounded measurements reverse the above procedures.

Electro Scientific Industries, Inc.

13900 N.W. SCIENCE PARK DRIVE
PORTLAND, OREGON 97229
(area code 503) 641-4141
TELEX No. 360273

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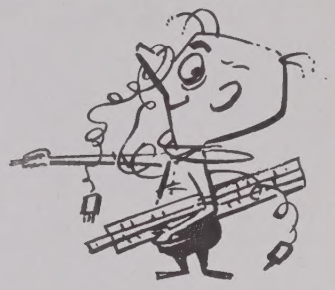

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☐ EB10 Effects of Output Loading on Resistive Voltage Dividers, *October 1969*

☐ EB15 Low Input Resistance Voltage Dividers, *February 1970*

☐ EB17 Accuracy vs. Frequency of Models 290B and 250DE Universal Impedance Bridges, *(revised May 1969)*

☐ EB26 International System of Units, *August 1969*

☐ EB29 DC and Low Frequency AC Ratio Measurements, *Dr. Merle L. Morgan, September 1962*

☐ EB30 Traceability of Resistance Measurement, *Jack Riley, January 1964*

☐ EB34 Resistance Transfer Technique, *Lawrence H. White, (revised April 1968)*

☐ EB35 An Improved Technique for Establishing Resistance Ratios, *R. M. Pailthorp and J. C. Riley, November 1962*

☐ EB41 Derivation of Electrical Units from Fundamental Standards, *R. D. Kuykendall and R. M. Pailthorp, July 1964*

☐ EB44 DC measurements Using Ratio Techniques, *Jack C. Riley, September 1965*

☐ TA2 A Ratio Transformer Bridge for Standardization of Inductors and Capacitors, *D. L. Hillhouse and H W. Kline, August 1960*

☐ TA6 The Accuracy of Series and Parallel Connections of Four-Terminal Resistors, *Jack C. Riley, April 1965*

☐ TA8 AC Measurements Using Ratio Techniques, *Jack C. Riley, May 1965*

☐ TA14 The Advantages of a Ten Kilohm Transportable Resistance Standard, *Robert M. Pailthorp, September 1967*

☐ TA16 Which Bridge for Precise Resistance Measurements? *Edward J. Swenson and George D. Vincent, December 1967*

☐ TA17 Experimental Verification of the Five-Terminal, Ten-Kilohm Resistor as a Device for Dissemination of the Ohm, *R. M. Pailthorp and George Vincent, December 1968*

☐ TA22A Laser Resistance Trimming from the Measurement Point of View, *Arthur G. Albin and Edward J. Swenson, June 1971*

☐ TA23 Precision Measurement of Resistor Networks, *Robert M. Pailthorp and Jack C. Riley, June 1971*

☐ TA24 Predictive Adjustment of Tantalum Film Resistors by Anodization, *Donald R. Cutler and Edward J. Swenson, July 1971*

☐ TA25 Laser Trimming Analysis Using a Resistive Sheet Analogy, *Swenson, Vincent, Riley, December 1972*

☐ TA26 The Effects of Laser Trimming on Birox and 1100 Series Thick Film Composition, *N. S. Spann, R. Headley, G. D. Vincent and E. J. Swenson, October 1971*

☐ TA27 Laser Trimming Thin Film Precision Resistor Networks with an Automated System, *Leonhard Groth, January 1974*

☐ TA28 YAG Laser Trimming of Thick Film Resistors, *Headley, Popowich, Anders, January 1974*

☐ TA31 A Method of Obtaining Optimum Trimming Performance from a Laser System, *Paul F. Parks and Thomas W. Richardson, October 1974*

☐ TA32 Laser Trimming RC Active Filters, *Edward J. Swenson, April 1978*

☐ TA33 Reducing Post Trim Drift of Thin Film Resistors By Optimizing YAG Laser Output Characteristics, *June 1978*

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